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BMC Neuroscience

Poster presentation

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Influence of external input on waxing and waning of neuronal network oscillations

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from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P257 doi:10.1186/1471-2202-10-S1-P257

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P257

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Introduction

Experimental observations have reported modulation of cortical oscillations as phases of high synchronization (waxing) followed by periods of reduced synchronization (waning) [1-3]. Although the phenomenon is present in almost all frequency bands, it is still not understood how this is driven. Here we study whether this phenomenon can occur in a network of inhibitory (I) and excitatory (E) cells and what effect external inputs have.

Methods

Using NEURON, we model a network of N_e excitatory and N_i inhibitory cells such that $N_e/N_i = 4$. The cells have a single compartment, and include passive channels and voltage dependent Na^+, K^+ channels. Synaptic connections are random, projecting GABA synapses from I to I and I to E cells and AMPA synapses from E to E and E to I cells. To stimulate the network, each cell receives a baseline of current and a stream of spikes delivered at random intervals across the simulated period.

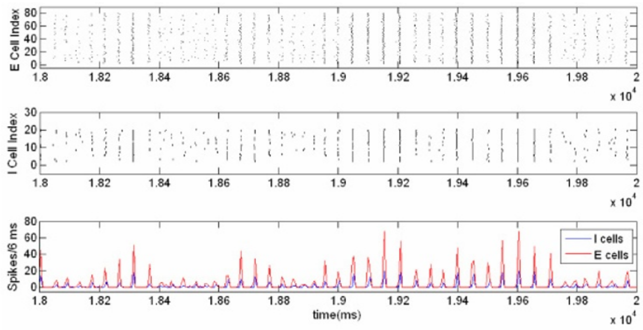

Figure 1
Raster plots of E (top) and I (middle) populations, during waxing and waning of a beta oscillation, and firing rate histograms (bottom).

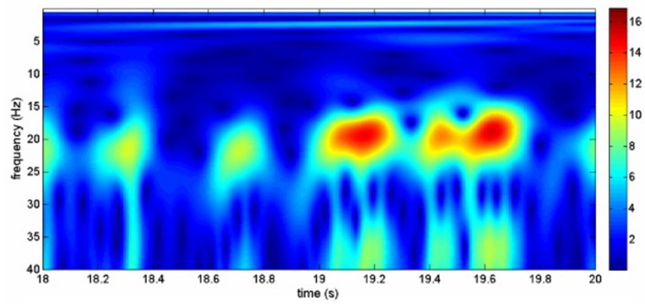

Figure 2
Wavelet transform of the activity in the E population for the same time period as shown in figure 1.

Results

We show that in a stable oscillatory network, waxing and waning occurs without the need for other synaptic mechanisms than the spike generating K^+ and Na^+ channels. The phenomenon can be modulated by changing the characteristics of the external input, such as number of spikes, mean inter-spike interval, randomness and whether E or I cells receive the external input. See figures 1 and 2.

Acknowledgements

The work was supported by the EU grant MC-RTN NEURoVERS-it (019247).

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